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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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WELLS ST. JOHN ROBERTS GREGORY & MATKIN P.S.
601 W. FIRST AVENUE
SUITE 1300
SPOKANE, WA 99201-3828

EXAMINER

CANTELMO, GREGG

ART UNIT	PAPER NUMBER
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1745

DATE MAILED: 12/23/2002

14

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/785,858

Applicant(s)

LEIPHART

Examiner

Gregg Cantelmo

Art Unit

1745

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 02 December 2002.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 35-74 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 35-74 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s). _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ | 6) <input type="checkbox"/> Other: |

DETAILED ACTION

Response to Amendment

1. In response to the amendment received December 9, 2002:
 - a. The prior art rejections stand.

Request for Continued Examination

2. The RCE received December 9, 2002 has been entered.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

4. Claims 35-45 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb, all of record and for the reasons of record.

Besser discloses a method of sputtering (a PVD process) aluminum or aluminum alloy films on a semiconductor, then sputtering a titanium film on the aluminum layer, and thereafter sputtering a titanium nitride film on the alloy layer (abstract; col. 3, ll. 5-24; col. 4, ll. 13-51 as applied to claims 35, 49 and 58). During the deposition of the titanium layer the film is heated to approximately 350° C and by teaching of an upper limit of 450 ° C, can also be set above 360 ° C (paragraph bridging columns 3 and 4).

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After completion of the films on the substrate, the substrate is removed from the tool to allow for the processing of additional substrates. The titanium layer is deposited to 100 angstroms (col. 4, ll. 22 as applied to claims 36 and 37). The first layer can be either aluminum or an aluminum alloy (col. 3, ll. 12-15 as applied to claims 38 and 39). The layer deposited atop the aluminum is physical vapor deposited titanium (col. 4, ll. 12-15 as applied to claim 40). The titanium and titanium nitride layers are formed in the same chamber 230 (col. 4, ll. 12-15 and 29-33 as applied to claim 42). The titanium is deposited on the first layer of aluminum or aluminum alloy in a second processing chamber 230 and at the upper temperature for processing the titanium will form an alloy of the titanium and aluminum (as applied to claim 43).

The differences between the instant claims and Besser are that Besser does not disclose forming the outermost portion of the aluminum layer at a temperature of 400° C or more (claim 35); or of preventing the outermost portion from cooling below 360° C during deposition of the first titanium layer (claim 35); or of forming the layers into a conductive line (claim 35); of forming the outermost portion of the aluminum layer at a temperature of 360° C or more (claim 41); of the first deposition temperature being at least 450° C (claim 44); of the first deposition temperature being greater than 450° C (claim 45).

With respect to forming the outermost portion of the aluminum layer at temperatures of at least 360 ° C and at least 400° C (claims 35 and 41):

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Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to preventing the temperature of the outermost portion of the aluminum film from going below 360° C (claims 35, 44, and 45):

As discussed above, Besser teaches that the titanium is heater within a range from 250° C to 450 ° C, with an approximate exemplified temperature of 350° C. Besser also recognized that the Ti reacts with Al to form $TiAl_3$ (col. 4, ll. 24-29). It is also known that maintaining temperatures of greater than 350° C will ensure reaction between titanium and aluminum to readily form $TiAl_3$. Marieb discloses sputtering titanium over the aluminum layer and that heating the device from a range of about 350° C-450° C accelerates the reaction between the titanium and aluminum to form the

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desired TiAl_3 product. The thickness of the film can be optimized so that all of all of the titanium film is reacted (col. 4, ll. 3-20).

Thus it would have been obvious to maintain the temperature to be greater than 350°C , held to be about 360°C , since it would have provided requisite temperature conditions to react the depositing titanium with the aluminum. TiAl_3 increases the electromigration lifetime of the film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by ensuring that the temperature of the first layer does not go below about 360°C during deposition of the titanium since it would have provided optimal temperature conditions wherein the depositing titanium would have reacted with the aluminum to form a layer of TiAl_3 . Such a layer being known to have increased the electromigration lifetime of the multilayer device.

With respect to forming a conductive line (claim 35):

Colgan discloses forming an interconnect for a semiconductor device where an aluminum alloy film is sputtered on a substrate, with subsequent Ti and TiN sputtered in succession. The layers are then photolithographically etched to form pattern lines (Col. 2, line 62 through col. 3, line 7; col. 4, ll. 34-40).

The motivation for patterning the deposited layers is to form wiring patterns useful in interconnect structures.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by patterning the deposited layers as taught by Colgan since it would have formed wiring patterns for forming interconnects.

Response to Arguments

5. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

Applicant argues that because Besser alone does not teach, suggest or render obvious forming the outermost portion of the aluminum layer at a temperature of at least 400° C or the recited deposition of titanium without letting the outermost portion of the first layer cool below 360° C.

Thus, according to Applicant, Besser does not obviate the teachings of claim 35.

This argument is not persuasive since the Examiner does not rely on Besser alone to teach these limitations. The context of the prior art rejection as set forth above is held to obviate the invention of claim 35 as set forth above.

Applicant argues that the Examiner does not provide any rationale as to how the Marieb disclosure suggests depositing of titanium on a first layer comprising aluminum without letting at least an outer portion of the first layer to cool below 360° C and forming the alloy during deposition of titanium.

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Marieb teaches of the deposition of the layers and then that heat in a range of about 350° C to 450° C is applied to accelerate the chemical reaction between the aluminum and titanium.

Second it is held that the combined teachings of Besser and Marieb suggest such a temperature condition.

As discussed above, Besser discloses depositing a first layer of aluminum, then depositing a second layer of titanium layer atop the aluminum layer and a third layer of titanium nitride atop the titanium layer. Thus the primary reference discloses the same layer arrangement as recited in the instant claims.

Besser teaches of heating the substrate during titanium deposition in a range from 250° C to 450° C with an exemplified temperature of 350° C. Besser further recognized that during this deposition step the titanium will react with the aluminum to form TiAl_3 .

Marieb teaches that by applying heat in a range from 350-450° C to a substrate having a layer of aluminum or an aluminum alloy adjacent to a layer of titanium, the reaction between the titanium and aluminum is accelerated to form TiAl_3 .

Besser teaches of a deposition temperature from 250° C to 450° C of the various aluminum and titanium layers. Marieb teaches that at temperatures from 350° C to 450° C, the reaction between the aluminum and titanium is accelerated thereby increasing the rate of formation of a TiAl_3 layer. Such a layer is increasingly important as a way of reducing hillocking and improving the electromigration lifetime of an interconnect (Marieb, col. 3, ll. 49-60).

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One of ordinary skill in the art would have found it obvious to maintain the temperature of the aluminum film to be within the range of 350° to 450°, in light of the combined teachings of Besser and Marieb since it would have provided a temperature for the aluminum and titanium materials to react thereby forming a TiAl₃ layer. If the temperature of the aluminum adjacent to the titanium layer were to drop below the lower threshold of the range taught by Marieb, the aluminum would not be at a temperature sufficient to cause the formation of TiAl₃.

Thus one of ordinary skill in the art would have found it obvious to modify the deposition temperature of Besser to be within a narrower range from 350° C to 450° C (which encompasses a temperature of at least 360° C) during deposition of the layers to accelerate the reaction between the aluminum and titanium is accelerated thereby increasing the rate of formation of a TiAl₃ layer since the presence of a TiAl₃ layer would have reduced hillocking and improved the electromigration lifetime of an interconnect.

With respect to Shan:

Applicant argues that Shan does not disclose or suggest depositing an outermost portion of a first layer of aluminum at a temperature of at least 400° C and then depositing titanium or the aluminum-titanium alloy.

Applicant's argument is not persuasive in the context in which Shan is applied. Applicant fails to provide a clear basis for the unobviousness of *Besser in view of Shan*.

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In response to applicant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Applicant's response argues Shan alone and does not provide reasoning as to why the combination of references as set forth in the rejection above is not obvious.

Besser teaches of forming an Al or Al alloy metallization feature and then depositing a Ti and TiN layer over the metallization feature.

In filling the contact with the Al or Al alloy, Shan teaches that it is desired to deposit the latter portion of the Al or Al alloy (which would be the outermost portion relative to the substrate) at a temperature of about 400° C to 500° C to allow for the deposited metal to reflow through the grain and improve the planarization of the aluminum film.

Therefore the teachings of Besser in view of Shan for maintaining a temperature of the outermost portion of at least 400° C is obvious since it would have allowed for the deposited metal to reflow through the grain and improve the planarization of the aluminum film.

With respect to Colgan:

Applicant argues that Colgan does not disclose or suggest formation of a first layer comprising aluminum and the deposition of titanium on the first layer without

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letting the outermost portion of the first layer cool to form a titanium aluminum alloy during deposition.

Applicant's argument is not persuasive in the context in which Colgan is applied. Applicant fails to provide a clear basis for the unobviousness of *Besser in view of Shan*.

In response to applicant's arguments against the references individually, one cannot show nonobviousness by attacking references individually where the rejections are based on combinations of references. See *In re Keller*, 642 F.2d 413, 208 USPQ 871 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 231 USPQ 375 (Fed. Cir. 1986). Applicant's response argues Shan alone and does not provide reasoning as to why the combination of references as set forth in the rejection above is not obvious.

Colgan is applied to show that the concept of patterning conductive lines is well known in the art. Colgan is not applied to Besser with respect to the deposition temperatures nor does it have to since the remaining prior art of record, Shan and Marieb have been applied to the temperature limitations.

Claim Rejections - 35 USC § 103

6. Claims 46-48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 35-45 above, all of record and for the reasons of record.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 46-48).

The claim limitations include a cooling by zero degrees (or less).

Besser forms the claimed structure and recognized the applicability of temperature ranges for the deposition of titanium from 250-450° C. Furthermore to change the titanium sputtered material to TiAl₃ it is advantageous to set the deposition temperature to be from 350-450° C to increase the electromigration lifetime of the device (Marieb). Shan also teaches that temperatures of 400-500° C are desirable when forming the outer portion of an aluminum film to provide adequate reflow of the aluminum to reduce void formation and form planar films.

Thus it would be apparent to form the aluminum film outer portion in a range of 400-500° C as taught by Shan and thereafter form the titanium film in a range of 350-500° C. Noting an overlap of these ranges, one of ordinary skill would have further found it obvious to use temperatures that overlap to provide optimal conditions with which both films can be formed without the need for changing process variables. Thus a temperature near or about that which both of these films can be deposited to achieve the desired result would have been preferred to reduce the process time required for setting different temperature conditions.

In addition the limitations set forth in claims 46-48 are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Boesche, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). In re Aller, 220

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F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

Response to Arguments

7. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

See item 5 above, incorporated herein.

Claim Rejections - 35 USC § 103

8. Claims 49-51 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb, all of record and for the reasons of record.

Besser discloses a method of sputtering (a PVD process) aluminum or aluminum alloy films on a semiconductor, then sputtering a titanium film on the aluminum layer,

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and thereafter sputtering a titanium nitride film on the alloy layer (abstract; col. 3, ll. 5-24; col. 4, ll. 13-51 as applied to claim 49). During the deposition of the titanium layer the film is heated to approximately 350° C and by teaching of an upper limit of 450 ° C, can also be set above 360 ° C (paragraph bridging columns 3 and 4). After completion of the films on the substrate, the substrate is removed from the tool to allow for the processing of additional substrates. The titanium layer is deposited to 100 angstroms (col. 4, ll. 22 as applied to claims 55 and 56). The first layer can be either aluminum (col. 3, ll. 12-15 as applied to claim 57).

The differences between the instant claims and Besser are that Besser does not disclose forming the outermost portion of the aluminum layer at a temperature of 400° C or more (claim 49); or of preventing the outermost portion from cooling below 360° C during deposition of the first titanium layer (claim 49); or of forming the layers into a conductive line (claim 49); of the first deposition temperature being at least 450° C (claim 50); of the first deposition temperature being greater than 450° C (claim 51).

With respect to forming the outermost portion of the aluminum layer at temperatures of at least 400° C (claim 49):

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to preventing the temperature of the outermost portion of the aluminum film from going below 360° C (claims 49-51):

As discussed above, Besser teaches that the titanium is heater within a range from 250° C to 450 ° C, with an approximate exemplified temperature of 350° C. Besser also recognized that the Ti reacts with Al to form TiAl_3 (col. 4, ll. 24-29). It is also known that maintaining temperatures of greater than 350° C will ensure reaction between titanium and aluminum to readily form TiAl_3 . Marieb discloses sputtering titanium over the aluminum layer and that heating the device from a range of about 350° C-450° C accelerates the reaction between the titanium and aluminum to form the desired TiAl_3 product. The thickness of the film can be optimized so that all of all of the titanium film is reacted (col. 4, ll. 3-20).

Thus it would have been obvious to maintain the temperature to be greater than 350° C, held to be about 360° C, since it would have provided requisite temperature

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conditions to react the depositing titanium with the aluminum. $TiAl_3$ increases the electromigration lifetime of the film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by ensuring that the temperature of the first layer does not go below about $360^{\circ}C$ during deposition of the titanium since it would have provided optimal temperature conditions wherein the depositing titanium would have reacted with the aluminum to form a layer of $TiAl_3$. Such a layer being known to have increased the electromigration lifetime of the multilayer device.

With respect to forming a conductive line (claim 49):

Colgan discloses forming an interconnect for a semiconductor device where an aluminum alloy film is sputtered on a substrate, with subsequent Ti and TiN sputtered in succession. The layers are then photolithographically etched to form pattern lines (Col. 2, line 62 through col. 3, line 7; col. 4, ll. 34-40).

The motivation for patterning the deposited layers is to form wiring patterns useful in interconnect structures.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by patterning the deposited layers as taught by Colgan since it would have formed wiring patterns for forming interconnects.

R sponse to Arguments

9. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

See item 5 above, incorporated herein.

Claim Rejections - 35 USC § 103

10. Claims 52-54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 49-51 and 55-57 above, all of record and for the reasons of record.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 46-48).

The claim limitations include a cooling by zero degrees (or less).

Besser forms the claimed structure and recognized the applicability of temperature ranges for the deposition of titanium from 250-450° C. Furthermore to change the titanium sputtered material to TiAl₃ it is advantageous to set the deposition temperature to be from 350-450° C to increase the electromigration lifetime of the device (Marieb). Shan also teaches that temperatures of 400-500° C are desirable when forming the outer portion of an aluminum film to provide adequate reflow of the aluminum to reduce void formation and form planar films.

Thus it would be apparent to form the aluminum film outer portion in a range of 400-500° C as taught by Shan and thereafter form the titanium film in a range of 350-500° C. Noting an overlap of these ranges, one of ordinary skill would have further

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found it obvious to use temperatures that overlap to provide optimal conditions with which both films can be formed without the need for changing process variables. Thus a temperature near or about that which both of these films can be deposited to achieve the desired result would have been preferred to reduce the process time required for setting different temperature conditions.

In addition the limitations set forth in claims 46-48 are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Boesche, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

Response to Arguments

11. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

See item 5 above, incorporated herein.

Claim Rejections - 35 USC § 103

12. Claims 58-60 and 62-71 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb, all of record and for the reasons of record.

Besser discloses a method of sputtering (a PVD process) aluminum or aluminum alloy films on a semiconductor, then sputtering a titanium film on the aluminum layer, and thereafter sputtering a titanium nitride film on the alloy layer (abstract; col. 3, ll. 5-24; col. 4, ll. 13-51 as applied to claim 58). During the deposition of the titanium layer the film is heated to approximately 350° C and by teaching of an upper limit of 450 ° C, can also be set above 360 ° C (paragraph bridging columns 3 and 4). After completion of the films on the substrate, the substrate is removed from the tool to allow for the processing of additional substrates. The titanium nitride is formed atop the titanium layer within chamber 230 (as applied to claim 59). The titanium and third layer are formed in the same chamber 230 (as applied to claim 62). The first aluminum layer is formed in a first chamber and the titanium and third layer are formed in the same chamber 230 without moving the substrate therefrom (as applied to claims 63-64). The

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titanium layer is deposited to 100 angstroms (col. 4, ll. 22 as applied to claims 67 and 68). The first layer can be either aluminum or an aluminum alloy (col. 3, ll. 12-15 as applied to claims 69 and 70). The layer deposited atop the aluminum is physical vapor deposited titanium (col. 4, ll. 12-15 as applied to claim 71).

The differences between the instant claims and Besser are that Besser does not disclose forming the outermost portion of the aluminum layer at a temperature of 400° C or more (claim 58); or of preventing the outermost portion from cooling below 360° C during deposition of the first titanium layer (claim 58); or of forming the layers into a conductive line (claim 58) of alloying all of the titanium with the aluminum (claim 60); of the first deposition temperature being at least 450° C (claim 65); of the first deposition temperature being greater than 450° C (claim 66).

With respect to forming the outermost portion of the aluminum layer at temperatures of at least 400° C (claim 58):

Shan teaches that the remainder of the metal is deposited while the semiconductor wafer is held at a relatively high temperature (e.g., when the metal is an aluminum alloy, about 400° C. to about 500° C which allows the deposited metal to reflow through grain. The hot aluminum deposition can be continued until a fully planarized surface is obtained.

The motivation for depositing the outermost portion of the aluminum at temperatures of at least 400° C is to provide reflow of the aluminum film.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by depositing the outer portion of the aluminum at a temperature of at least 400° C since it would have allowed the deposited metal to reflow through the grain and provided optimal conditions for forming a planarized aluminum film.

With respect to preventing the temperature of the outermost portion of the aluminum film from going below 360° C (claims 58 and 60):

As discussed above, Besser teaches that the titanium is heater within a range from 250° C to 450 ° C, with an approximate exemplified temperature of 350° C. Besser also recognized that the Ti reacts with Al to form $TiAl_3$ (col. 4, ll. 24-29). It is also known that maintaining temperatures of greater than 350° C will ensure reaction between titanium and aluminum to readily form $TiAl_3$. Marieb discloses sputtering titanium over the aluminum layer and that heating the device from a range of about 350° C-450° C accelerates the reaction between the titanium and aluminum to form the desired $TiAl_3$ product. The thickness of the film can be optimized so that all of all of the titanium film is reacted (col. 4, ll. 3-20).

Thus it would have been obvious to maintain the temperature to be greater than 350° C, held to be about 360° C, since it would have provided requisite temperature conditions to react the depositing titanium with the aluminum. $TiAl_3$ increases the electromigration lifetime of the film.

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Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by ensuring that the temperature of the first layer does not go below about 360° C during deposition of the titanium since it would have provided optimal temperature conditions wherein the depositing titanium would have reacted with the aluminum to form a layer of TiAl₃. Such a layer being known to have increased the electromigration lifetime of the multilayer device.

With respect to forming a conductive line (claim 58):

Colgan discloses forming an interconnect for a semiconductor device where an aluminum alloy film is sputtered on a substrate, with subsequent Ti and TiN sputtered in succession. The layers are then photolithographically etched to form pattern lines (Col. 2, line 62 through col. 3, line 7; col. 4, ll. 34-40).

The motivation for patterning the deposited layers is to form wiring patterns useful in interconnect structures.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by patterning the deposited layers as taught by Colgan since it would have formed wiring patterns for forming interconnects.

R sponse to Arguments

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13. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

See item 5 above, incorporated herein.

Claim Rejections - 35 USC § 103

14. Claims 72-74 are rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 58-60 and 62-71 above, all of record and for the reasons of record.

The difference not yet discussed is cooling the outermost portion of the first layer from the first deposition temperature by about 25° C or less (claims 72-74).

The claim limitations include a cooling by zero degrees (or less).

Besser forms the claimed structure and recognized the applicability of temperature ranges for the deposition of titanium from 250-450° C. Furthermore to change the titanium sputtered material to TiAl₃ it is advantageous to set the deposition temperature to be from 350-450° C to increase the electromigration lifetime of the device (Marieb). Shan also teaches that temperatures of 400-500° C are desirable when forming the outer portion of an aluminum film to provide adequate reflow of the aluminum to reduce void formation and form planar films.

Thus it would be apparent to form the aluminum film outer portion in a range of 400-500° C as taught by Shan and thereafter form the titanium film in a range of 350-500° C. Noting an overlap of these ranges, one of ordinary skill would have further found it obvious to use temperatures that overlap to provide optimal conditions with

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which both films can be formed without the need for changing process variables. Thus a temperature near or about that which both of these films can be deposited to achieve the desired result would have been preferred to reduce the process time required for setting different temperature conditions.

In addition the limitations set forth in claims 46-48 are drawn to particular ranges of temperatures and does not appear to provide any novel effect not achieved by the process conditions set forth in the prior art of record.

Generally, differences in ranges will not support the patentability of subject matter encompassed by the prior art unless there is evidence indicating such ranges is critical. In re Boesche, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). In re Aller, 220 F.2d 454, 456, 105 USPQ 233, 235 (CCPA 1955). In re Hoeschele, 406 F.2d 1403, 160 USPQ 809 (CCPA 1969).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser such that any temperature relationship between the first and second films was applied so long as the temperatures achieved the same resultant multilayer device as formed by the prior art of record above. Furthermore, it has been held that when the difference between a claimed invention and the prior art is the range or value of a particular variable, then a prima facie rejection is properly established when the difference in the range or value is minor. Titanium Metals Corp. of Am. v. Banner, 778 F.2d 775, 783, 227 USPQ 773, 779 (Fed. Cir. 1985).

Response to Arguments

15. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

See item 5 above, incorporated herein.

Claim Rejections - 35 USC § 103

16. Claim 61 is rejected under 35 U.S.C. 103(a) as being unpatentable over Besser in view of Shan, Colgan and Marieb as applied to claims 58-60 and 62-71 above, all of record and for the reasons of record.

The difference not yet discussed is depositing each film in a separate chamber.

Besser has a forth chamber for depositing additional films. Besser prefers to deposit the titanium and titanium nitride in the same chamber however Besser recognized that it is known in the art to deposit the titanium and titanium nitride films in separate chambers (col. 2, ll. 5-25). The benefit for separating the titanium and titanium nitride into different chambers is to prevent cross-contamination of the respective films for successive substrates. The only apparent benefit disclosed by Besser for using a single chamber to form both the Ti and TiN films is to improve the throughput of the system.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Besser by forming each film in separate chambers since it would have enhanced the purity of each film deposited in the multilayer arrangement.

Response to Arguments

17. Applicant's arguments filed December 9, 2002 have been fully considered but they are not persuasive.

See item 5 above, incorporated herein.

Conclusion

18. This is an RCE of applicant's earlier Application No. 09/785,858. All claims are drawn to the same invention claimed in the earlier application and could have been finally rejected on the grounds and art of record in the next Office action if they had been entered in the earlier application. Accordingly, **THIS ACTION IS MADE FINAL** even though it is a first action in this case. See MPEP § 706.07(b). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no, however, event will the statutory period for reply expire later than **SIX MONTHS** from the mailing date of this final action.

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19. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Gregg Cantelmo whose telephone number is (703) 305-0635. The examiner can normally be reached on Monday through Thursday from 8:00 a.m. to 5:30 p.m. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Pat Ryan, can be reached on (703) 308-2383. FAX communications should be sent to the appropriate FAX number: (703) 872-9311 for After Final Responses only; (703) 872-9310 for all other responses. FAXES received after 4 p.m. will not be processed until the following business day. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

gc

December 16, 2002


Patrick Ryan
Supervisory Patent Examiner
Technology Center 1700